APPENDIX B.

CAM ILLUSTRATIONS

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B.1 FABRIC FILTERS[1-6]

Fabric filters, frequently referred to as baghouses, are typically used to control particulate matter emissions in exhaust gas streams. Certain gases may also be removed through interactions with the dust layer. Fabric filters are normally used where a high control efficiency is required and where exhaust gas streams conditions are within the limitations of fabric filter operation. These limitations are high moisture, high temperatures, and exhaust gas constituents that attack the fabric or hinder the cleaning process (such as sticky particulate).

Three types of baghouses (pulse-jet, reverse-air, and shaker) are in common use, categorized by the method used for filter cleaning. Various fabric filter materials can be used in each type, depending on temperature, corrosiveness and moisture content of the gas stream, as well as dimensional stability and cost of the selected material. Important design parameters for baghouses are the gas-to-cloth (G/C) ratio (ft^3 per minute gas/ft^2 fabric), which is somewhat dependent on particle size and grain loading, as well as operating temperatures and the cleaning mechanism. Minimum operating temperature is especially important where acid gases are expected to be present in the gas stream, while cleaning mechanisms and maximum temperature may dictate the type of cloth that can be used.

Each type of baghouse presents different maintenance and monitoring challenges to the facility operators, particularly in relation to cleaning mechanisms and bag materials. Effective cleaning is desirable in order to maintain a low pressure-drop across the baghouse, which saves energy. This must be balanced, however, against the increased particulate removal efficiency which follows buildup of a dust layer on the fabric.

1. Pulse-jet systems use a blast of high-pressure (60 to 120 psi) air to back flush the bags. This can be accomplished with the baghouse on-line. Moisture and oil present in plant air must be removed, or potential bag blinding can result from caking particulate. Equipment must be able to withstand the repeated stress of the pulses.
2. Reverse-air systems use a longer, gentler back flush of low-pressure air (a few inches water column) to clean the bags. Cleaning air is provided to each compartment by a separate, smaller fan and duct system. Since the cleaning is at low pressure, each compartment must be effectively isolated from the gas stream during the cleaning cycle.
3. Many different shaking schemes have been introduced. Shaker systems must also be taken off-stream for cleaning, which is accomplished by a mechanism which vigorously shakes the bags. Combination reverse air/shaker systems are also in use.
4. Sonic horns have been developed which augment reverse-air and shaker cleaning. Acoustic vibration in the range of 150 to 550 Hz at 120 to 140 dB helps dislodge particles during the regular cleaning cycle.

Opacity is the typical method used for baghouse performance monitoring; a continuous opacity monitor may be used, or opacity (Method 9) or visible emissions (similar to Method 22) observations may be made by plant personnel. Triboelectric monitors, light scattering monitors, beta gauges, or acoustic monitors may also be used. Parameter monitoring usually includes pressure drop, sometimes in conjunction with exhaust gas temperature. An increase in pressure drop may indicate blinding of the fabric. A decrease in temperature may indicate inleakage of outside air, which may cool the exhaust gas stream below its dew point (important if condensible emissions are involved). Temperature excursions may damage the filter bags. Other parameters that may be monitored include gas flow rate, pulse jet compressed air pressures, and reverse air cleaning cycle static pressure drop.

Common baghouse problems and malfunctions include: broken or worn bags; blinding of the filter media; failure of the cleaning system; leaks in the system or between filter bag and tube sheet; reentrainment of dust; wetting of the bags; plugging of manometer lines; malfunction of dampers or material discharge equipment; and low fan speed. The following illustrations present compliance assurance monitoring options for fabric filters:

- 1a: Daily observations of visible emissions (VE) or opacity using RM 9 or modified RM 22.
- 1b: Continuous instrumental monitoring of opacity using COMS or other analytical device.
- 1c: Monitoring pressure drop across baghouse.
- 1d: Fabric filter condition monitoring.
- 1e: Use of a bag leak detection monitor.

CAM ILLUSTRATION
No. 1a. FABRIC FILTER FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018]. Also applicable to other PM control devices

1.2 Pollutants
Primary: Particulate matter (PM, PM-10)
Other: Toxic heavy metals

1.3 Process/Emissions units: Industrial process vents and fuel combustion units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Opacity of emissions or visible emissions (VE).

2.2 Rationale for Monitoring Approach: Changes in opacity and changes in VE observations indicate process changes, changes in baghouse efficiency, or leaks.

2.3 Monitoring Location: Per RM 9 (opacity) or RM 22 (VE) requirements.

2.4 Analytical Devices Required: Trained observer using RM 9 or visible/no visible emissions observation techniques (RM 22-like).

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Daily or as weather permits
- Reporting units: Percent opacity or visible/no visible emissions
- Recording process: Observers complete opacity or VE observation forms and log into binder or electronic data base as appropriate.

2.6 Data Requirements
- Baseline VE observations concurrent with emission test or historical plant records of opacity observations. (No data are needed if indicator is "any visible emissions.")

2.7 Specific QA/QC Procedures: Initial training of observer per RM 9 or RM 22, semi-annual refresher training per RM 9, if applicable

2.8 References: 1, 2, 3, 4, 5

3. COMMENTS

3.1 Although RM 22 applies to fugitive sources, the visible/no visible emission observation techniques of RM 22 can be applied to ducted emissions. For situations where no visible emissions are the norm, a technique focused towards identifying a change in performance as indicated by any visible emission is a useful and effective technique. The use of the visible/no visible emissions technique reduces the need for onsite certified RM 9 observers.

3.2 For large pollutant specific emission units (post control potential to emit equal to or greater than 100 percent of the amount required for a source to be classified as a major source), CAM requires the owner or operator to collect four or more data values equally spaced over each hour, unless the permitting authority approves a reduced frequency. Therefore, this monitoring approach may not be acceptable for large emission units unless used in conjunction with other appropriate parameter monitoring for which data are recorded at least four times each hour; e.g., baghouse pressure drop, air flow, temperature. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 1b. FABRIC FILTER FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018]; also applicable to other PM control devices

1.2 Pollutants
Primary: Particulate matter (PM, PM-10)
Other: Toxic heavy metals

1.3 Process/Emissions units: Industrial process vents and fuel combustion units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Opacity

2.2 Rationale for Monitoring Approach: An increase in opacity indicates process changes, changes in baghouse efficiency, or leaks.

2.3 Monitoring Location: Exhaust gas outlet

2.4 Analytical Devices Required: Opacity meter or COMS as appropriate for gas stream

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Once per shift if instruments read manually, or continuously recorded on strip chart or digital data acquisition system
- Reporting units: Percent opacity for COMS, or applicable units for other type monitors
- Recording process: Operators log data readings, or recorded automatically on strip chart or digital data acquisition system as appropriate

2.6 Data Requirements
- Baseline monitoring data (e.g., opacity for COMS) concurrent with emission test, or historical plant records of monitoring data

2.7 Specific QA/QC Procedures: Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4, 5

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per shift would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 1c. FABRIC FILTER FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018]
1.2 Pollutants
Primary: Particulate matter (PM, PM-10)
Other: Toxic heavy metals
1.3 Process/Emissions units: Industrial process vents and fuel combustion units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Pressure drop
2.2 Rationale for Monitoring Approach
- Decrease in pressure drop indicative of bag failure
- Increase in pressure drop indicative of fabric blinding or decreased permeability

2.3 Monitoring Location: Across inlet and outlet of each compartment of control device
2.4 Analytical Devices Required: Pressure transducers, differential pressure gauges, manometers, other methods and/or alternative instrumentation as appropriate; see Section 4.3 for additional information on devices.
2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Once during each shift, or recorded continuously on strip chart or digital data acquisition system
- Reporting units: Inches of water column (in. w.c.) or pounds per square inch (psi)
- Recording process: Operators log data manually, or automatically recorded by data logger system

2.6 Data Requirements
- Baseline pressure drop measurements and cleaning cycle concurrent with emission test, or historical plant records on pressure drop measurements

2.7 Specific QA/QC Procedures: Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.
2.8 References: 1, 2, 3, 4, 5

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per shift would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 1d. FABRIC FILTER FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016]
1.2 Pollutants
Primary: Particulate matter (PM, PM-10)
Other: Toxic heavy metals
1.3 Process/Emissions units: Incinerators, furnaces, kilns, and other high temperature process units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Pressure drop and inlet temperature
2.2 Rationale for Monitoring Approach
- Pressure drop: Decrease in pressure drop indicative of bag failure; increase in pressure drop indicative of fabric blinding or decreased permeability
- Temperature: Excessive temperature can lead to leaks, breakdown of filter material, and reduced lifetime of filter; temperatures below the dewpoint of the exhaust gas stream may also damage the filter bags

2.3 Monitoring Location
- Pressure drop: Across inlet and outlet of each compartment of control device
- Temperature: At fabric filter inlet duct

2.4 Analytical Devices Required
- Pressure drop: Pressure transducers, differential pressure gauges, manometers, other methods and/or alternative instrumentation as appropriate
- Temperature: Thermocouple, RTD, or other temperature sensing device; see Section 4.2 for additional information on devices.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Once during each shift, or recorded continuously on strip chart or digital data acquisition system
- Reporting units
  - Pressure drop: Inches of water column (in. w.c.) or pounds per square inch (psi)
  - Temperature: Degrees Fahrenheit (°F) or Celcius (°C)
- Recording process: Operators log data manually, or automatically recorded by data logger system

2.6 Data Requirements
- Baseline pressure drop measurements and cleaning cycle concurrent with emission test, or historical plant records on pressure drop measurements
- Temperature specifications for fabric filter material

2.7 Specific QA/QC Procedures: Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4, 5

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per shift would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 1e. FABRIC FILTER FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018], other PM control devices.

1.2 Pollutants
Primary: Particulate matter (PM, PM-10)
Other: Toxic heavy metals

1.3 Process/Source Type: Industrial process vents and fuel combustion units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicator to be Monitored: Bag leak detection monitor signal.

2.2 Rationale for Monitoring Approach: Bag leak detectors that operate on principles such as triboelectricity, electrostatic induction, light scattering, or light transmission, produce a signal that is proportional to the particulate loading in the baghouse exhaust gas stream. When bag leaks occur, the cleaning peak height or baseline signal level will increase. Alarm levels based on increases in normal cleaning peak heights or the normal baseline signal can be set to detect filter bag leaks.

2.3 Monitoring Locations: Baghouse, control room

2.4 Analytical Devices Required: Bag leak detector and associated instrumentation.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Continuous
- Reporting units: Amps, volts, or percent of scale
- Recording process: Strip chart or electronic data acquisition system

2.6 Data Requirements
- Historical signal data showing baseline level and cleaning peak height during normal operation or signal data concurrent with emission testing.

2.7 Specific QA/QC Procedures: Calibrate, maintain, and operate instrumentation using procedures that take into account manufacturer's specifications.

2.9 References: 1, 5, 6

3. COMMENTS

None.

B.2. ELECTROSTATIC PRECIPITATORS[1,7-9]

[To be completed]

The following illustration presents one approach to compliance assurance monitoring for an ESP:

2: Monitoring primary and secondary voltage and current, spark rate.

CAM ILLUSTRATION
No. 2. ESP FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Electrostatic precipitator (ESP) [010, 011, 012]
1.2 Pollutants
Primary: Particulate matter (PM)
Other:
1.3 Process/Emissions units: Furnaces, combustors

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Primary and secondary voltage and current, spark rate.
2.2 Rationale for Monitoring Approach: Operating with these parameters outside of normal (design) specifications indicates a change in particulate collection efficiency.
2.3 Monitoring Location: Current and voltage at each transformer and spark rate in each section.
2.4 Analytical Devices Required: Ammeters, voltmeters, other methods or instrumentation as appropriate; see Section 4.6 for additional information on devices.
2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly, if readings taken manually, or continuously, if recorded by distributed control system (DCS) or similar digital data acquisition system
- Reporting units: Amps, volts, sparks per minute, as appropriate
- Recording process: Operators periodically observe process and log data, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements
- Baseline ESP operating parameter records and sampling data concurrent with emission test or historical plant records of ESP performance parameters

2.7 Specific QA/QC Procedures: Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer’s specifications.
2.8 References: 1, 3, 7, 8, 9, 10, 11, 12

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.3 WET ELECTROSTATIC PRECIPITATORS[1,7-9,13]

[To be completed]

B.4 WET SCRUBBERS[8,9,14]

[To be completed]

The following illustrations demonstrate approaches to compliance assurance monitoring for wet scrubbers:

Particulate emissions:

4a: Monitoring pressure drop.

SO_2:

5: Monitoring scrubber liquid pH and liquid flow rate.

6: Monitoring pressure drop, alkali solution concentration, and flow rate.

CAM ILLUSTRATION

No. 4a. WET SCRUBBER FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Wet scrubber [001, 002, 003]; also applicable to spray towers [052], venturi scrubbers [053], impingement scrubbers [055], and wet cyclonic scrubber [085]

1.2 Pollutants

Primary: Particulate matter (PM)

Other:

1.3 Process/Emissions Unit: Combustors, mineral processing units, furnaces, kilns.

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Differential pressure

2.2 Rationale for Monitoring Approach: Increase in pressure drop indicates clogging or increased gas flow; decrease in pressure drop indicates decrease in gas or liquid flow or poor liquid distribution.

2.3 Monitoring Location: Across inlet and outlet ducts

2.4 Analytical Devices Required: Differential pressure transducer, differential pressure gauge, manometers, or alternative methods/instrumentation; see Section 4.3 for information on specific types of instruments.

2.5 Data Acquisition and Measurement System Operation

- Frequency of measurement: Hourly, if manually read, or continuously, if by automatic system.
- Reporting units: inches of water column (in. w.c.) or pounds per square inch (psi)
- Recording process: Operators periodically observe gauges and log data, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements

- Baseline pressure drop records and sampling data concurrent with emission test; or
- Historical plant records of pressure drop

2.7 Specific QA/QC Procedures

- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 8, 9, 14

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 5. WET SCRUBBER FOR SO_2 CONTROL

1. APPLICABILITY

1.1 Control Technology: Wet scrubber [001, 002, 003]; also applicable to gas scrubbers (general) [013], gas column absorber (packed or tray type) [050, 051]

1.2 Pollutants
Primary: SO_2
Other: Acid gases

1.3 Process/Emissions Unit: Combustors

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Scrubber liquid pH and liquid flow rate

2.2 Rationale for Monitoring Approach: pH level and liquid flow rate indicative of proper operation for removal of SO_2 and other acid gases from exhaust stream

2.3 Monitoring Location: pH at scrubber liquor inlet; liquid flow rate at pump discharge or at scrubber liquor inlet

2.4 Analytical Devices Required: pH meter for pH; liquid flow meter, pump discharge pressure gauge, or other device for liquid flow; see Section 4.4 for information on specific types of instruments.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly, if manually read, or continuously, if by automatic system; daily calculation of quantity of SO_2 removed based
- Reporting units: pH units for pH, cubic feet per minute (ft^3/min) for liquid flow
- Recording process: Operators periodically observe gages and log data, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements
- Baseline pH and liquid flow rate concurrent with emission test

2.7 Specific QA/QC Procedures
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 9, 14

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 6. SPRAY DRYER FOR SO_2 CONTROL

1. APPLICABILITY

1.1 Control Technology: Spray drying
1.2 Pollutants
Primary: Sulfur oxides (SO_x)
Other:
1.3 Process/Emissions units: Combustors, furnaces, boilers

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Pressure drop, alkali solution concentration and flow rate
2.2 Rationale for Monitoring Approach: Pressure drop is indicative of proper functioning of spray dryer. Removal of acid gas components is dependent on availability of adequate alkali as indicated by slurry alkalinity and flow rate.
2.3 Monitoring Location: Pressure drop measured across inlet and outlet of spray dryer. Alkali concentration measured at slurry header and recirculation pump discharge. Slurry flow rate at slurry header.
2.4 Analytical Devices Required: Differential pressure gauges, in-line pH meters, in-line flow meters, other methods and instrumentation as appropriate; see Sections 4.3 (Pressure), 4.4 (Flow), and 4.5 (pH and Conductivity) for additional information on devices.
2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly pressure drop, pH measurements and flow; or monitored continuously by distributed control system (DCS) or similar means. Automatic alarm activated when pH or flow falls below indicator range.
- Reporting units: Inches of water column (in. w.c.) or pounds per square inch (psi); alkali concentration in pH units; flow in gal/hr.
- Recording process: Operators take readings and log manually, or automatically on strip chart recorder or digital data acquisition system. Alarm activation incidents manually recorded in log book

2.6 Data Requirements
- Historical operating data on flow and pH to give adequate warning to avoid noncompliance events

2.7 Specific QA/QC Procedures: Calibration, maintenance, and operation of pressure transducers, gauges, flow meters, and pH sensors using procedures that take into account manufacturer's specifications
2.8 References: 9, 14

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.5 THERMAL OXIDIZERS[1-2,15-16]

Thermal oxidizers or thermal incinerators are combustion systems that control VOC, CO, and volatile HAP by combusting them to carbon dioxide (CO_2) and water. The design of an incineration system is dependent on the pollutant concentration in the waste gas stream, type of pollutant, presence of other gases, level of oxygen, and stability of processes vented to the system. Important design factors include residence time (sufficient time for the combustion reaction to occur), temperature (a temperature high enough to ignite the waste-auxiliary fuel mixture), and turbulence (turbulent mixing of the air and waste-fuel). Time, temperature, turbulence, and sufficient oxygen concentration govern the completeness of the combustion reaction. Of these, only temperature and oxygen can be significantly controlled after construction. Time and turbulence are fixed by incinerator design and flow rate can be controlled only over a limited range.

The rate at which VOC compounds and CO are oxidized is greatly affected by temperature; the higher the temperature the faster the oxidation reaction proceeds. Because inlet gas concentrations are well below the lower explosive limit (LEL) to prevent preignition explosions, the gas must be heated with auxiliary fuel above the autoignition temperature. Thermal destruction of most organics occurs at combustion temperatures between 800°F and 2000°F. Residence time is equal to the incinerator chamber volume divided by the total flow of flue gases (waste gas flow, added air, and products of combustion). A residence time of 0.2 to 2.0 seconds, a length-to-diameter ratio of 2 to 3 for the chamber dimensions, and an average gas velocity of 10 to 50 feet per second are common. Turbulence, or good mixing, is necessary to ensure that all waste and fuel come in contact with oxygen. Because 100 percent turbulence is not achieved, excess air/oxygen is added (above stoichiometric or theoretical amount) to ensure complete combustion.

Normal operation of a thermal incinerator should include a fixed outlet temperature, or an outlet temperature above a minimum level. A variety of operating parameters that may be used to indicate good operation include: inlet and outlet VOC concentration, outlet incinerator temperature, auxiliary fuel input, fuel pressure (magnehelic gauge), fan current (ammeter), inlet waste gas temperature to heat exchanger, outlet waste gas temperature from heat exchanger, outlet carbon monoxide concentration, and outlet oxygen concentration. Common monitoring parameters for thermal incinerators include monitoring of incinerator combustion temperature, waste gas flow, fan current, and outlet CO concentration. Several different approaches to compliance assurance monitoring for thermal incinerators are presented in the following illustrations:

CO:

11a: Continuous combustion chamber temperature monitoring and annual burner inspection.

11b: Continuous outlet CO concentration monitoring.

VOC:

16a: Continuous combustion chamber temperature monitoring and annual burner inspection.

16b: Continuous combustion chamber temperature, annual burner inspection, and exhaust gas flow rate monitoring.

16c: Continuous combustion chamber temperature monitoring and continuous outlet CO concentration monitoring.

CAM ILLUSTRATION
No. 11a. THERMAL INCINERATOR FOR CO CONTROL

1. APPLICABILITY

1.1 Control Technology: Thermal incinerator [021]; also applicable to direct flame afterburners with or without heat exchangers [021, 022], boilers, or similar devices for controlling CO emissions by combustion

1.2 Pollutants
Primary: Carbon monoxide (CO)
Other: Volatile organic compounds (VOC's)

1.3 Process/Emissions units: Fluid catalytic cracking unit (FCCU) catalyst regenerators; petroleum refining

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Combustion chamber temperature and annual burner inspection

2.2 Rationale for Monitoring Approach:
- Combustion chamber temperature: Low temperature indicates potential for insufficient destruction of CO.
- Annual burner inspection: Maintain proper burner operation and efficiency.

2.3 Monitoring Location: Outlet of combustion chamber

2.4 Analytical Devices Required: Thermocouples, or other temperature measurement device; see Section 4.2 for additional information on devices.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly or recorded continuously on strip chart or digital data acquisition system
- Reporting units: Degrees Fahrenheit or Celsius (°F, °C)
- Recording process: Operators take readings and log data manually, or automatically recorded on digital data acquisition system.

2.6 Data Requirements: Baseline temperature measurements concurrent with emission test, historical plant records of temperature, or manufacturer's data and recommended operating ranges.

2.7 Specific QA/QC Procedures: Calibrate, maintain, and operate thermocouples using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 11b. THERMAL INCINERATOR FOR CO CONTROL

1. APPLICABILITY

1.1 Control Technology: Thermal incinerator [021]; also applicable to direct flame afterburners with or without heat exchangers [021, 022], boilers, or similar devices for controlling CO emissions by combustion

1.2 Pollutants
Primary: Carbon monoxide (CO)
Other: Volatile organic compounds (VOC's)

1.3 Process/Emissions units: Fluid catalytic cracking unit (FCCU) catalyst regenerators; petroleum refining

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Outlet gas carbon monoxide concentration

2.2 Rationale for Monitoring Approach: Provides direct indicator of CO emissions.

2.3 Monitoring Location: Combustion chamber outlet

2.4 Analytical Devices Required: Nondispersive infrared (NDIR) analyzer or other methods or instrumentation.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly, if instruments read manually; continuously, if CEMS
- Reporting units: Parts per million by volume (ppm_v), dry basis
- Recording process: Operators take readings and log manually, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements
- Baseline CO concentration measurements, or historical plant records of CO concentrations or CEMS records.

2.7 Specific QA/QC Procedures: Calibrate, maintain, and operate CEMS using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

3.2 Concentration measurements, CO concentration in terms of ppm can be used as an indicator of control device performance even if the emission standard is a mass emissions standard (i.e., lb/hr); additional information (e.g., flow) to calculate/report emission in units of the standard is not required for CAM; however, such a measurement may be a monitoring requirement of the applicable requirement.

CAM ILLUSTRATION
No. 16a. THERMAL INCINERATOR FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Thermal incinerator [021]; also applicable to direct flame afterburners with or without heat exchangers [021, 022], boilers, or similar devices for controlling VOC emissions by combustion

1.2 Pollutants
Primary: Volatile organic compounds (VOC's)
Other: Higher molecular weight organic compounds

1.3 Process/Emissions units: Coating, spraying, printing, polymer manufacturing, distillation units, wastewater treatment units, air oxidation units, petroleum refining, miscellaneous SOCMI units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Combustion chamber temperature and annual burner inspection.

2.2 Rationale for Monitoring Approach:
- Combustion chamber temperature: Proper temperature range can be related to good performance
- Annual burner inspection: Maintain proper burner operation and efficiency.

2.3 Monitoring Location: Outlet of combustion chamber

2.4 Analytical Devices Required: Thermocouples, RTD's, or alternative methods/instrumentation as appropriate for specific gas stream; see Section 4.2 (Temperature) for additional information on devices.

2.5 Data Acquisition and Measurement System Operation:
- Frequency of measurement: Hourly, or recorded continuously on strip chart or digital data acquisition system.
- Reporting units: Degrees Fahrenheit or Celsius (°F, °C)
- Recording process: Operators take readings and manually log data, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements:
- Baseline incineration temperature measurements and outlet VOC concentration or destruction efficiency measurements concurrent with emission test; or
- Historical plant records on incineration temperature measurements

2.7 Specific QA/QC Procedures:
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 16b. THERMAL INCINERATOR FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Thermal incinerator [021]; also applicable to direct flame afterburners with or without heat exchangers [021, 022], for controlling VOC emissions by combustion

1.2 Pollutants
Primary: Volatile organic compounds (VOC's)
Other: Higher molecular weight organic compounds

1.3 Process/Emissions units: Coating, spraying, printing

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Combustion chamber temperature, annual burner inspection, and exhaust gas flow rate

2.2 Rationale for Monitoring Approach
- Combustion chamber temperature: Proper temperature range can be related to good performance.
- Exhaust gas flow rate: Maintaining proper flow through the entire control system is important for maintaining capture efficiency.
- Annual burner inspection: Maintain proper burner operation and efficiency.

2.3 Monitoring Location
- Combustion chamber temperature: Outlet of combustion chamber
- Exhaust gas flow rate: Incinerator outlet or fan instrumentation

2.4 Analytical Devices Required
- Combustion chamber temperature: Thermocouples, RTD's, or alternative methods/instrumentation as appropriate for specific gas stream.
- Exhaust gas flow rate: Differential pressure flow device, fan motor ammeter, or other type of device that measures gas velocity or flow rate

2.5 Data Acquisition and Measurement System Operation:
- Frequency of measurement: Hourly, or recorded continuously on strip chart or digital data acquisition system.
- Reporting units
  – Combustion chamber temperature: Degrees Fahrenheit or Celsius (°F, °C)
  – Exhaust gas flow rate: Cubic feet per minute (ft^3/min); amps if fan motor current
- Recording process: Operators take readings and manually log data, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements:
- Baseline combustion chamber temperature measurements, exhaust gas flow rate measurements, and outlet VOC concentration or destruction efficiency measurements concurrent with emission test; or
- Historical plant records on combustion chamber temperature and exhaust gas flow rates

2.7 Specific QA/QC Procedures:
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 16c. THERMAL INCINERATOR FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Thermal incinerator [021; also applicable to direct flame afterburners with or without heat exchangers [021, 022], boilers, or similar devices for controlling VOC emissions by combustion

1.2 Pollutants
Primary: Volatile organic compounds (VOC's)
Other: High molecular weight organic compounds

1.3 Process/Emissions Unit: Coating, spraying, printing, polymer manufacturing, distillation units, wastewater treatment units, air oxidation units, petroleum refining, miscellaneous SOCMI units

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Combustion chamber temperature and outlet CO concentration.

2.2 Rationale for Monitoring Approach
- Combustion chamber temperature: Proper temperature range can be related to good performance.
- Outlet CO concentration: CO is a product of incomplete combustion and is an indicator of combustion efficiency.

2.3 Monitoring Location:
- Combustion chamber temperature: Outlet of combustion chamber
- Outlet CO concentration: Outlet to incinerator

2.4 Analytical Devices Required
- Combustion chamber temperature: Thermocouples, RTD's, or alternative methods/instrumentation as appropriate for specific gas stream.
- Outlet CO concentration: Nondispersive infrared (NDIR) analyzer calibrated to manufacturer's specifications, or other methods or instrumentation.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly if manually read, or recorded continuously on strip chart or data acquisition system;
- Reporting units
  – Combustion chamber temperature: Degrees Fahrenheit or Celsius (°F, °C)
  – Outlet CO concentration: parts per million by volume (ppmv), dry basis
- Recording process: Operators take readings and manually log data, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements

- Baseline combustion chamber temperature measurements, outlet CO concentration measurements, and outlet VOC concentration or destruction efficiency measurements concurrent with emission test; or
- Historical plant records on combustion chamber temperature and outlet CO concentrations.

2.7 Specific QA/QC Procedures:

- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4, 15, 16

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.6 CATALYTIC OXIDIZERS[1-2,15,16]

Catalytic oxidizers are oxidation systems (similar to thermal incinerators) that control VOC. Catalytic oxidizers use a catalyst to promote the oxidation of VOC's to carbon dioxide and water (i.e., increase the kinetic rate). Catalytic oxidizer control devices are common in surface coating industries.

The design of the incineration system is dependent on the pollutant concentration, type of pollutant, presence of other gases, level of oxygen, and stability of processes vented to the system. Important design factors for catalytic oxidizers include residence time (sufficient residence time in the catalyst bed for the oxidation reaction to occur), temperature (an operating temperature high enough to oxidize the waste gas on the catalyst), VOC concentration and species, catalyst characteristics, and the presence of poisons or masking agents in the waste gas. Time, temperature, turbulence, and the presence of sufficient oxygen govern the completeness of the combustion reaction. Of these, only the oxygen and the temperature can be significantly controlled after construction. Time and turbulence are fixed by incinerator design and flow rate can be controlled only over a limited range.

The rate at which VOC compounds are oxidized is greatly affected by temperature; the higher the temperature the faster the oxidation reaction proceeds. The operating temperature needed to achieve a particular VOC efficiency depends on the species of pollutants, concentration, and the catalyst type. Each pollutant has a temperature which must be reached to initiate the catalytic oxidation reaction. The initiation temperature is also dependent on the type of catalyst. The use of the catalyst allows the combustion reaction to occur at a lower temperature than the autoignition temperature. Catalytic oxidizers operate between 650°F and 1000°F.

The catalyst support and bed geometry influence the size and shape of the catalyst bed chamber and affects the pressure drop across the bed. The catalyst typically lasts 2 to 5 years. Thermal aging over the lifetime of the catalyst and particulates and catalyst poisons in the inlet gas streams reduce the catalyst's ability to promote the oxidation reaction by masking and coating the catalyst and preventing contact between VOC and the catalyst surface.

Turbulence, or good mixing, is necessary to ensure that all waste and fuel come in contact with oxygen. Good turbulence exposes the fuel and pollutants to oxygen in a rapid manner, promoting rapid combustion. Because 100 percent turbulence is not achieved, excess air/oxygen is added (above stoichiometric or theoretical amount) to ensure complete combustion. For catalytic oxidizers, good mixing of the waste gas and oxygen promotes uniform oxidation in the catalyst bed and avoids localized heating of bed sections.

Normal operation of a catalytic oxidizer should include a fixed inlet temperature and some increase in outlet temperature. A thermocouple is placed at the inlet to the catalyst bed to measure the temperature of the preheated waste gas stream. A thermocouple at the outlet to the catalyst bed chamber measures temperature; this thermocouple is connected to a controller that maintains the desired catalyst bed chamber temperature by altering the rate of auxiliary fuel. A variety of operating parameters that may be used to indicate good operation include: outlet VOC concentration, temperature prior to catalyst bed, temperature after catalyst bed, outlet waste gas temperature from heat exchanger, pressure drop across oxidizer sections (preheat, catalyst bed, heat exchanger), auxiliary fuel input, outlet carbon monoxide concentration, and outlet oxygen concentration.

The most common monitoring for catalytic oxidizers for indicators of normal oxidizer operation and heat recovery includes the inlet waste gas temperature, the catalyst bed temperature, the outlet gas temperature, and outlet CO concentration. Temperature rise across the bed is also an indication of VOC efficiency. One approach to compliance assurance monitoring for catalytic oxidizers is presented in the following illustration:

18: Continuous preheat chamber temperature (i.e., inlet to the catalyst bed) and outlet gas temperature monitoring.

CAM ILLUSTRATION
No. 18. CATALYTIC OXIDIZER FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Catalytic incinerator [019]; also applicable to catalytic afterburners with or without heat exchangers [019, 020]

1.2 Pollutants
Primary: Volatile organic compounds (VOC's)
Other: High molecular weight organic compounds

1.3 Process/Emissions Unit: Coating, spraying, printing, polymer manufacturing, distillation units, wastewater treatment units, air oxidation units, petroleum refining, miscellaneous SOCMI units

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Catalyst inlet and outlet gas stream temperatures

2.2 Rationale for Monitoring Approach
- Catalyst inlet gas temperature: Allows determination of temperature of gas flowing into catalyst bed to ensure bed is maintained within design temperature range
- Catalyst outlet gas temperature: Indication that combustion is occurring on the catalyst bed, allows for calculation of temperature differential across bed.

2.3 Monitoring Location:
- Inlet gas temperature: Preheat chamber outlet
- Outlet gas temperature: Catalyst bed outlet

2.4 Analytical Devices Required
- Inlet and outlet temperatures: Thermocouples, RTD's, or alternative methods/instrumentation as appropriate for specific gas stream.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly if manually read, or recorded continuously on strip chart or data acquisition system; continuously if CEMS.
- Reporting units: Degrees Fahrenheit or Celsius (°F, °C)
- Recording process: Operators take readings and manually log data, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements
- Baseline catalyst inlet and outlet gas temperatures or
- Historical plant records on catalyst inlet and outlet gas temperatures.

2.7 Specific QA/QC Procedures:
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4, 15, 16

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.7 FLARES[2,9,15]

[To be completed]

The requirements for flares contained in § 60.18 (general control device requirements) have been designated as presumptively acceptable monitoring for CAM by the EPA. Section 60.18 requires that flares be operated with a pilot flame present at all times and that the presence of the flare pilot flame be monitored using a thermocouple or equivalent device to detect the presence of a pilot flame. Section 60.18 also states that flares shall be designed for and operated with no visible emissions, except for periods not to exceed a total of 5 minutes in any 2 consecutive hours, as determined by Method 22. There is no frequency of monitoring specified for Method 22 observations, however (i.e., § 60.18 does not require routine monitoring of VE). Owners or operators may propose presumptively acceptable monitoring without additional justification, except that (1) for new or modified monitoring systems, the owner/operator must submit information on the method to be used to confirm operational status of the monitoring equipment and, (2) unless specifically stated otherwise by an applicable requirement, the owner/operator must monitor indicators to detect any bypass of the control device, if such bypass can occur, as required in § 64.3(a)(2). Subparts NNN, RRR, and WWW of Part 60 already require monitoring of an indicator of diversion of gas flow from the flare.

B.8 CONDENSERS[1-2]

[To be completed]

Different approaches to compliance assurance monitoring for condensers are presented in the following illustrations:

21a: Continuous outlet gas temperature monitoring.
21b: Continuous inlet coolant temperature and outlet coolant temperature monitoring.

CAM ILLUSTRATION
No. 21a. CONDENSER FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Condenser [072, 073, 074]
1.2 Pollutants
Primary: Volatile organic compounds (VOC's)
1.3 Process/Emissions Unit: Coating, polymer manufacturing, distillation units, equipment leaks, air oxidation units, miscellaneous reactors, pharmaceuticals

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Outlet gas temperature
2.2 Rationale for Monitoring Approach: Condenser operating temperature affects removal efficiency; an increase in operating temperature decreases removal efficiency
2.3 Monitoring Location: Outlet vent of condenser
2.4 Analytical Devices Required: Thermocouples, RTD's, or alternative methods/instrumentation as appropriate for specific gas stream or specific equipment design; see Section 4.2 (Temperature) for additional information on devices.
2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly, or recorded continuously on strip chart or data acquisition system.
- Reporting units: Degrees Fahrenheit or Celsius (°F, °C)
- Recording process: Operators take readings and manually log data, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements
- Baseline outlet gas temperature measurements and outlet VOC concentration measurements;
- Calculations indicating outlet temperature necessary to achieve compliance; or
- Historical plant records on outlet gas temperature measurements.

2.7 Specific QA/QC Procedures:
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 21b. CONDENSER FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Condenser [072, 073, 074]
1.2 Pollutants: Volatile organic compounds (VOC's)
1.3 Process/Emissions units: Coating, polymer manufacturing, distillation units, equipment leaks, air oxidation units, miscellaneous reactors, pharmaceuticals

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Inlet and outlet coolant temperature
2.2 Rationale for Monitoring Approach: Condenser operating temperature affects removal efficiency; an increase in operating temperature decreases removal efficiency
2.3 Monitoring Location: Front and rear end heads
2.4 Analytical Devices Required: Thermocouples, RTD's , or alternative methods/instrumentation as appropriate for specific gas stream or specific equipment design; see Section 4.2 (Temperature) for additional information on devices.
2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly, or recorded continuously on strip chart or digital data acquisition system
- Reporting units: Degrees Fahrenheit or Celsius (°F, °C)
- Recording process: Operators take readings and log data manually, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements:
- Baseline coolant temperature measurements exhaust gas measurements and outlet VOC concentration measurements concurrent with emission test;
- Calculations indicating outlet temperature necessary to achieve compliance, baseline outlet gas temperature measurements concurrent with coolant temperature measurements; or
- Historical plant records on coolant temperature measurements.

2.7 Specific QA/QC Procedures:
- Annual process review to determine process or materials changes that could affect the initial determination of condensation parameters
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.9 ELECTRIFIED FILTER BEDS[13]

[To be completed]

B.10 CARBON ADSORBERS

[To be completed].

The following illustration presents one approach to compliance assurance monitoring for carbon bed adsorbers used to control VOC:

23a: Monitoring outlet VOC concentration.

CAM ILLUSTRATION
No. 23a. CARBON ADSORBER FOR VOC CONTROL

1. APPLICABILITY

1.1 Control Technology: Carbon adsorption system [048]

1.2 Pollutants
Primary: Volatile organic compounds (VOC's)
Other: Higher molecular weight organic compounds

1.3 Process/Emissions units: Coating, spraying, printing, polymer manufacturing, distillation units, wastewater treatment units, dry cleaning, degreasing, pharmaceuticals, equipment leaks

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Outlet VOC concentration

2.2 Rationale for Monitoring Approach: Increasing outlet VOC concentration indicates breakthrough of VOC's through adsorbent bed

2.3 Monitoring Location: At adsorber outlet duct or stack

2.4 Analytical Devices Required: Flame ionization detectors (FID's), photoionization detectors (PID's), diffusion sensors, alternative methods/instrumentation as appropriate for specific gas stream

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Hourly, or recorded continuously on strip chart or digital data acquisition system
- Reporting units: Parts per million (ppm)
- Recording process: Operators take readings and manually log data, or recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements:
- Baseline outlet VOC concentration and historical plant records on outlet VOC concentration measurements

2.7 Specific QA/QC Procedures: Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2, 3, 4

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.11 CYCLONES

[To be completed].

The following illustrations provide example approaches for compliance assurance monitoring of cyclones and gravity collectors used to control PM:

24a: Monitoring cyclone inlet gas flow rate.
24b: Monitoring pressure drop across cyclone.
25: Monitoring gravity collector inlet gas flow rate.

CAM ILLUSTRATION
No. 24a. CYCLONE FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Cyclone [075]; also applicable to multiclones with or without fly ash reinjection [076, 077], centrifugal collectors [007, 008, 009], and other types of mechanical collectors and dry inertial separators

1.2 Pollutants
Primary: Particulate matter (PM)
Other: Heavy metals

1.3 Process/Emissions Unit: Combustors, mineral processing units, furnaces, kilns.

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Gas inlet velocity (flow rate)

2.2 Rationale for Monitoring Approach: Control efficiency increases with increased velocity; if inlet velocity exceeds a specific value, turbulence becomes excessive and control efficiency decreases

2.3 Monitoring Location: Gas inlet duct

2.4 Analytical Devices Required: Differential pressure flowmeter, anemometer, rotameter, or other type of device that measures gas velocity or flow rate; see Section 4.3 for information on specific types of instruments.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Once per shift, if manually read, or continuously, if by automatic system.
- Reporting units: Feet per minute (ft/min)
- Recording process: Operators periodically observe gauges and log data, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements
- Baseline gas velocity and sampling data concurrent with emission test; or
- Manufacturer's design specifications and efficiency curve/equation for inlet velocity or pressure drop.

2.7 Specific QA/QC Procedures
- Maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2

3. COMMENTS

3.1 Since this illustration applies to a PM source, visible emissions or opacity monitoring is also an appropriate performance indicator.

3.2 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 24b. CYCLONE FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Cyclone [075]; also applicable to multiclones with or without fly ash reinjection [076, 077], centrifugal collectors [007, 008, 009], and other types of mechanical collectors and dry inertial separators

1.2 Pollutants
Primary: Particulate matter (PM)
Other: Heavy metals

1.3 Process/Emissions Unit: Combustors, mineral processing units, furnaces, kilns.

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Pressure drop

2.2 Rationale for Monitoring Approach: Control efficiency is a function of inlet velocity, and changes in velocity result in changes in pressure drop across device; if inlet velocity exceeds a specific value, turbulence becomes excessive and control efficiency decreases.

2.3 Monitoring Location: Gas inlet and outlet ducts

2.4 Analytical Devices Required: Differential pressure transducer, differential pressure gauge, manometers, or alternative methods/instrumentation; see Section 4.3 for information on specific types of instruments.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Once per shift, if manually read, or continuously, if by automatic system.
- Reporting units: Inches of water column (in. w.c.) or pounds per square inch (psi)
- Recording process: Operators periodically observe gauges and log data, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements
- Baseline pressure drop and sampling data concurrent with emission test; or
- Manufacturer's design specifications and efficiency curve/equation for inlet velocity and pressure drop.

2.7 Specific QA/QC Procedures
- Maintain and operate instrumentation using procedures that take into account manufacturer's specifications.

2.8 References: 1, 2

3. COMMENTS

3.1 Since this illustration applies to a PM source, visible emissions or opacity monitoring is also an appropriate performance indicator.

3.2 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

CAM ILLUSTRATION
No. 25. GRAVITY COLLECTOR FOR PM CONTROL

1. APPLICABILITY

1.1 Control Technology: Gravity collectors [004, 005, 006], such as settling chambers, drop boxes, and other types of devices that use gravitational settling for PM control

1.2 Pollutants
Primary: Particulate matter (PM)
Other: Heavy metals

1.3 Process/Emissions Unit: Combustors, mineral processing units, furnaces, kilns.

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Gas velocity (flow rate)

2.2 Rationale for Monitoring Approach: Control efficiency is a function of residence time; an increase in velocity results in decreased residence time and collection efficiency.

2.3 Monitoring Location: Gas inlet duct

2.4 Analytical Devices Required: Differential pressure flowmeter, anemometer, rotameter, or other type of device that measures gas velocity or flow rate; see Section 4.3 for information on specific types of instruments.

2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Once per shift, if manually read, or continuously, if by automatic system.
- Reporting units: Velocity--feet per minute (ft/min); flow rate--cubic feet per minute (ft^3/min)
- Recording process: Operators periodically observe gauges and log data, or recorded automatically on strip chart or digital data acquisition system

2.6 Data Requirements
- Baseline gas velocity or flow rate, and sampling data concurrent with emission test; or
- Manufacturer's design specifications and efficiency curve/equation for inlet velocity.

2.7 Specific QA/QC Procedures
- Maintain and operate instrumentation using procedures that take into account manufacturer's specification.

2.8 References: 21

3. COMMENTS

3.1 Since this illustration applies to a PM source, visible emissions or opacity monitoring is also an appropriate performance indicator.

3.2 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

B.12 OTHER SO_2 CONTROLS

[When drafted, will discuss flue gas desulfurization, acid plant neutralization, dual absorption systems, and dry sorbent injection.]

B.13 NO_X CONTROLS

[To be completed].

CAM ILLUSTRATION
No. 32a. SELECTIVE CATALYTIC REDUCTION FOR NO_x CONTROL

1. APPLICABILITY

1.1 Control Technology: Selective catalytic reduction [065]; also applicable to all other types of NO_x controls
1.2 Pollutants
Primary: Nitrogen Oxides (NO_x)
Other: HNO_3, NH_3
1.3 Process/Emission Units: Nitric acid production units, glass manufacturing, acrylonitrile process, municipal waste combustors, steel reheating/annealing furnaces, boilers

2. MONITORING SYSTEM/PROGRAM DESCRIPTION

2.1 Indicators Monitored: Exhaust gas NO_2 concentration using continuous emission monitoring system (CEMS)
2.2 Rationale for Monitoring Approach: CEMS provides direct measurement of NO_x emission concentrations
2.3 Monitoring Location: Absorber tower exhaust stack, at least 2 diameters downstream from the point of pollution generation and ½ diameter upstream from the effluent exhaust
2.4 Analytical Devices Required: NO_2 CEMS, tank level meters or flow totalizer, hydrometer or density meter
2.5 Data Acquisition and Measurement System Operation
- Frequency of measurement: Continuous
- Reporting units: CEMS output is parts per million by volume (ppm_v) NO_2, which is converted to kg NO_x (expressed as NO_2) per metric ton HNO_3 (as 100% nitric acid) for reporting.
- Recording process: Plant-specific conversion factor is used to convert NO_2 concentration measured by CEMS to units of standard. Results are recorded automatically on strip chart or digital data acquisition system.

2.6 Data Requirements
- Baseline NO_2 concentration records and sampling data concurrent with emission test, or
- Historical plant records of production rates in terms of 100% acid, acid strength, hours of operation, and corresponding NO_2 concentrations

2.7 Specific QA/QC Procedures:
- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications; and
- Annual redetermination of conversion factor

2.8 References:

CAM ILLUSTRATION

No. 32b. SELECTIVE CATALYTIC REDUCTION FOR NO_x CONTROL

1. APPLICABILITY

1.1 Control Technology: Selective catalytic reduction [065]

1.2 Pollutants

Primary: Nitrogen Oxides (NO_x)

Other: HNO_3, NH_3

1.3 Process/Emission units: Nitric acid production units, glass manufacturing, acrylonitrile process, municipal waste combustors, steel reheating/annealing furnaces, boilers

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Catalyst deactivation, residual NH_3 concentration in flue gas (NH_3 slip causes ammonium sulfate fouling of the catalyst). The fuel sulfur content also has an impact on catalyst fouling.

2.2 Rationale for Monitoring Approach: SCR provides designed NO_x reduction until fouling occurs. Fouling of the catalyst is caused by ammonium sulfate salts, the formation of which can be avoided by limiting ammonia slip and limiting fuel sulfur content.

2.3 Monitoring Location: NH_3 monitored at outlet duct of catalytic converter.

2.4 Analytical Devices Required: NH_3 CEMS (other methods and instruments may be unit-specific).

2.5 Data Acquisition and Measurement System Operation

- Frequency of measurement: NH_3 monitored continuously, maintain records of fuel sulfur content.
- Reporting units: CEMS output is parts per million by volume (ppm_v) NH_3, fuel sulfur content in percent by weight.
- Recording process: CEMS results are recorded automatically on strip chart recorder or digital data acquisition system; fuel sulfur content manually recorded in SCR maintenance log.

2.6 Data Requirements

- Baseline NH_3 concentration records and sampling data concurrent with emission test; or
- Historical plant records of production rates in terms of 100% acid, acid strength, hours of operation, and corresponding NH_3 concentrations; and
- Historical plant records of fuel sulfur content

2.7 Specific QA/QC Procedures

- Calibrate, maintain and operate instrumentation using procedures that take into account manufacturer's specifications; and
- Annual redetermination of conversion factor

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